A Level Chemistry Transition Pack

A set of learning resources to help to prepare you for A Level Chemistry.

IMPORTANT – You are expected to complete and mark all the work within this pack, ready to hand in on the first lesson in September. You will be tested on this material during the first two weeks of term, with a minimum pass mark of 40%.

Definitions (that you need to learn and will be tested on!)

Word	Definition
Acid	A species that releases H^+ ions in aqueous solution.
Alkali	A type of base that dissolves in water forming OH^-(aq) ions.
Anhydrous	Containing no water molecules.
Aqueous	Substance dissolved in water
Avogadro's constant	The number of atoms per mole of the Carbon-12 isotope. (6.02×10^{23} mol $^{-1}$)
Base	A compound that neutralises an acid to form a salt.
Concentration	The amount of solute, in moles, dissolved in $1dm^3$ of solution.
Covalent bond	The strong electrostatic attraction between a shared pair of electrons and the nuclei of the bonded atoms.
Empirical formula	The formula that shows the simplest whole-number ratio of atoms of each element present in a compound.
Hydrocarbon	A compound of Hydrogen and Carbon only.
Ionic bonding	The electrostatic attraction between positive and negative ions.
Isotopes	Atoms of the same element with different numbers of neutrons and different mass numbers.
Metallic bond	The electrostatic attraction between positive metal ions and delocalised electrons.
Mass number	The sum of the protons and neutrons in the nucleus – also referred to as Nucleon number.
Mole	The amount of any substance containing as many elementary particles as there are carbon atoms in exactly 12g of the Carbon-12 isotope, which is 6.02×10^{23} particles.
Neutralisation	A chemical reaction in which an acid and base react together to form a salt and water.
Oxidation	Loss of electrons or an increase in oxidation number (also addition of oxygen)
Redox reaction	A reaction involving reduction and oxidation.

Reduction	Gain of electrons or a decrease in oxidation number (also loss of oxygen)
Relative atomic mass	The weighted mean mass of an atom of an element compared with one twelfth of the mass of an atom of Carbon-12.
Salt	The product of a reaction in which the H^+ ions from the acid are replaced by metal or ammonium ions

Brushing up your GCSE knowledge

Many of the topics we cover below will be familiar to you from GCSE but at A level you need to be able to apply your knowledge quickly and so the following sections are to help you boost your existing knowledge and to allow you to tackle exam questions of these types without worry.

If you get stuck look them up. Try BBC bitesize , Seneca learning or another resource you like.

Chemical Formula

Table of common ions:

1+	**1-**	**2+**	**2-**	**3+**
Lithium Li^+	Chloride Cl^-	Magnesium Mg^{2+}	Sulphate SO_4^{2-}	Aluminium Al^{3+}
Sodium Na^+	Bromide Br^-	Calcium Ca^{2+}	Carbonate CO_3^{2-}	Iron III Fe^{3+}
Potassium K^+	Iodide I^-	Zinc Zn^{2+}	Oxide O^{2-}	
Silver Ag^+	Hydroxide OH^-	Copper Cu^{2+}	Sulphide S^{2-}	
Ammonium NH_4^+	Nitrate NO_3^-	Lead Pb^{2+}		
Hydrogen H^+	Hydrogen Carbonate HCO_3^-	Iron II Fe^{2+}		

Wring a chemical formula – the rules

● Ionic compounds are neutral, so the number of positively charged ions and negatively charged ions in a formula must always be **equal** .
● Charges are never written in a chemical formula
● The number of ions in a formula is written aer the symbol and below the line, eg. $MgCl_2$ is made of 1 Mg ion and 2 Cl ions.
● Some ions contain more than one atom, such as NO_3^-. If you more than one of these ions in a formula, brackets must be used, eg. $(NO_3)_2$

Now use these rules to work out the formulae of the following compounds:

1)	calcium bromide	.....	11)	hydrogen bromide	.....
2)	aluminium fluoride	.....	12)	barium iodide	.....
3)	potassium sulphide	.....	13)	zinc sulfate	.....
4)	magnesium nitrate	.....	14)	ammonium carbonate	.....
5)	silver nitrate	.....	15)	iron (III) hydroxide	.....
6)	ammonium chloride	.....	16)	lithium oxide	.....
7)	copper carbonate	.....	17)	sodium sulfate	.....
8)	iron (II) sulfate	.....	18)	calcium hydroxide	.....
9)	iron (III) sulfate	.....	19)	potassium hydrogencarbonate	.....
10)	copper oxide	.....	20)	aluminium oxide	.....

Balancing Equations

Balancing chemical equations is the stepping stone to using equations to calculate masses in chemistry. The guidelines are:

● Calculate how many atoms of each type of are on either side of the equation
● If it is the same then it is balanced – job done.
● If it is not the same then the quantities of each part of the equation may need to be changed to make them balance. You can only change quantities by using a large number in front of the reactant or product and NOT small $_{\text{subscript}}$ numbers in the formula as the FORMULA MUST stay the SAME. (start with the elements that are not balanced first but remember you change the quantity of every atom in the molecule)
● Keep doing this until the numbers of each type of atom are the same on either side
● Check and make sure that these numbers are the smallest ratio they can be.

NB – Atoms cannot be created or destroyed so what you have at the beginning, you must have at the end.

Have a go at balancing these:

1) $Ca + H_2O \rightarrow Ca(OH)_2 + H_2$

2) $NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

3) $FeCl_3 + NaOH \rightarrow Fe(OH)_3 + NaCl$

4) $Al + H_2SO_4 \rightarrow Al_2(SO_4)_3 + H_2$

5) $MgO + HNO_3 \rightarrow Mg(NO_3)_2 + H_2O$

6) $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O$

7) $Ca(OH)_2 + HNO_3 \rightarrow Ca(NO_3)_2 + H_2O$

8) $PCl_3 + H_2O \rightarrow P(OH)_3 + HCl$

9) $Cu + HNO_3 \rightarrow Cu(NO_3)_2 + H_2O + NO$

10) $Pb_3O_4 + HNO_3 \rightarrow Pb(NO_3)_2 + PbO_2 + H_2O$

Moles

Counting atoms and molecules

Chemists are able to count atoms and molecules of different elements and compounds by weighing them. This is because atoms of different elements have different masses.

We call the mass of an atom, the **relative atomic mass, A_r.** This is defined as the average mass of all the atoms of an element relative to the mass of the carbon-12 isotope which is given exactly the mass of 12.

The mole is a number. It is equal to the number of atoms in 12g of the carbon 12 isotope. All relative atomic and molecular masses are compared to the mass of the carbon 12 isotope. So for all atoms and molecules, the atomic/molecular mass in grams always contains 1 mole of particles. This mass is often referred to as the **molar mass, relative atomic mass or relative molecular mass** .

The number of particles in one mole of a substance is called **Avogadro's Constant** and is equal to **6×10^{23}**.

Equal numbers of moles always contain the same number of particles and so the mole can be used as a link between chemical equations showing number of particles (stoichiometry) and reacting quantities (ie. masses of substances).

The link between mass and number of moles can be written as:

n = $\frac{\mathbf{m}}{\mathbf{Mr}}$ n = number of moles
m = mass in grams (g)
Mr = relative molecular mass

Formula Mass

Work out the formula mass of the following:

a) F_2 .....

b) Fe .....

c) H_2SO_4 .....

d) Al_2O_3 .....

e) $Mg(OH)_2$ .....

f) $Al(NO_3)_3$ .....

g) $(NH_4)_2SO_4$ .....

Moles Calculations

Calculate the number of moles in the following:

a) 90 g of H_2O .....

.....

b) 20 g of C_4H_{10} .....

.....

c) 680 g of NH_3 .....

.....

d) 100 g of O_2 .....

.....

e) 1 kg of Al_2O_3 .....

.....

f) 20 mg of Au .....

.....

Calculate the mass of the following:

a) 4 moles of N_2 .....

.....

b) 0.1 moles of HNO_3 .....

.....

c) 0.02 moles of K_2O .....

.....

d) 2.5 moles of PH_3 .....

.....

e) 0.40 moles of C_2H_5OH .....

.....

f) 10 moles of $Ca(OH)_2$ .....

.....

Reacting Masses

Try using what you know about moles to answer the following questions.

1) Aluminium is extracted from aluminium oxide as shown. Calculate the mass of aluminium that can be formed from 1020 g of aluminium oxide.

$2\ Al_2O_3 \rightarrow 4\ Al + 3\ O_2$

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.....

.....

2) Calculate the mass of oxygen needed to react 10 g of calcium to form calcium oxide.

$2\ Ca + O_2 \rightarrow 2\ CaO$

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.....

3) What mass of propane could burn in 50 g of oxygen?

$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$

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4) What mass of ammonia can be made from 20 g of hydrogen?

$3\ H_2 + N_2 \rightarrow 2\ NH_3$

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.....

.....

5) What mass of sodium hydroxide is needed to neutralise 10 kg of sulfuric acid?

$H_2SO_4 + 2\ NaOH \rightarrow Na_2SO_4 + 2\ H_2O$

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.....

6) What mass of carbon dioxide is formed when 10 g of copper carbonate decomposes on heating?

$CuCO_3 \rightarrow CuO + CO_2$

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Percentage Yield

We have seen how to work out how much product **should** be produced in a reaction using relative molecular mass (mole) calculations. This is called the **theoretical yield** . In reality, some product is always lost during the process of making the product so we never actually get the full amount. The amount of product actually made in an experiment is called the **actual yield** . We can calculate the actual yield as a percentage of the theoretical yield as follows:

Percentage yield = actual yield / theoretical yield x 100

Now try these:

1) Ammonia is made by reacting hydrogen with nitrogen. $3\,H_2 + N_2 \rightarrow 2\,NH_3$

a) Calculate the mass of ammonia that can be formed from 12 g of hydrogen.

.....

.....

.....

b) 20 g of ammonia was formed in this reaction. Calculate the percentage yield..

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.....

.....

2) Iron is made by reduction of iron oxide with carbon monoxide. $Fe_2O_3 + 3\,CO \rightarrow 2\,Fe + 3\,CO_2$

a) Calculate the mass of iron that can be formed from 100 g of iron oxide.

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b) 65 g of iron was formed in this reaction. Calculate the percentage yield.

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3) Chlorine can be made by the electrolysis of sodium chloride solution. $2\,NaCl + 2\,H_2O \rightarrow 2\,NaOH + Cl_2 + H_2$

a) Calculate the mass of chlorine that can be formed from 50 g of sodium chloride.

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.....

b) 25 g of chlorine was formed in this reaction. Calculate the percentage yield.

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.....

4) Chromium is a useful metal. It is extracted from chromium oxide by reaction with aluminium. $Cr_2O_3 + 2\,Al \rightarrow 2\,Cr + Al_2O_3$

a) Calculate the mass of chromium that can be formed from 1 kg of chromium oxide.

.....

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.....

b) 600 g of chromium was formed in this reaction. Calculate the percentage yield.

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.....

5) Titanium is made by the reaction of titanium chloride with sodium. $TiCl_4 + 4\,Na \rightarrow Ti + 4\,NaCl$

a) Calculate the mass of titanium that can be formed from 10 kg of titanium chloride.

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.....

c) 1950 g of titanium was formed in this reaction. Calculate the percentage yield.

.....

.....

Reactions of Acids

At A level we expect you to know the 4 reactions of acids that produce salts. In the space below, write out the general word equations for these reactions and then add an example of a specific reaction with an acid to get the salt.

Now fill in the blanks for the following equations:

1) zinc + sulfuric acid → .....

2) nitric acid + calcium carbonate → .....

3) potassium hydroxide + sulfuric acid → .....

4) nitric acid + calcium oxide → .....

5) nitric acid + ammonia → .....

6) ..... → calcium nitrate + hydrogen

7) ..... → lead sulfate + water

8) ..... → zinc sulfate + water + carbon dioxide

9) ..... → ammonium phosphate

10) calcium carbonate + ... → calcium chloride + ...

11) tin oxide + ... → tin chloride + ...

12) calcium hydroxide + ... → ..... + calcium nitrate

13) citric acid + potassium hydroxide → .....

14) ..... + citric acid → magnesium citrate + hydrogen

15) phosphoric acid + ... → potassium phosphate + water

ANSWERS

Please mark and make corrections for every question. Feel free to reattempt any questions you've got wrong – this is an excellent habit to get into and is by far the best way to learn! We expect your corrections to be in a different colour!

Chemical Formula

1) $CaBr_2$
2) AlF_3
3) K_2S
4) $Mg(NO_3)_2$
5) $AgNO_3$
6) NH_4Cl
7) $CuCO_3$
8) $FeSO_4$
9) $Fe_2(SO_4)_3$
10) CuO
11) HBr
12) BaI_2
13) $ZnSO_4$
14) $(NH_4)_2CO_3$
15) $Fe(OH)_3$
16) Li_2O
17) Na_2SO_4
18) $Ca(OH)_2$
19) $KHCO_3$
20) Al_2O_3

Balancing equations

1) $Ca + 2\,H_2O \rightarrow Ca(OH)_2 + H_2$

2) $2\,NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

3) $FeCl_3 + 3\,NaOH \rightarrow Fe(OH)_3 + 3\,NaCl$

4) $2\,Al + 3\,H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3\,H_2$

5) $MgO + 2\,HNO_3 \rightarrow Mg(NO_3)_2 + H_2O$

6) $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2\,H_2O$

7) $Ca(OH)_2 + 2\,HNO_3 \rightarrow Ca(NO_3)_2 + 2\,H_2O$

8) $PCl_3 + 3\,H_2O \rightarrow P(OH)_3 + 3\,HCl$

9) $Cu + 4\,HNO_3 \rightarrow Cu(NO_3)_2 + 2\,H_2O + 2\,NO_2$

10) $Pb_3O_4 + 4\,HNO_3 \rightarrow 2\,Pb(NO_3)_2 + PbO_2 + 2\,H_2O$

Formula Mass

a) F_2 38

b) Fe 56

c) H_2SO_4 98

d) Al_2O_3 102

e) $Mg(OH)_2$ 58

f) $Al(NO_3)_3$ 213

g) $(NH_4)_2SO_4$ 132

Moles Exercise 1

a) 90 g of H_2O — 90/18 = 5.00 moles

b) 20 g of C_4H_{10} — 20/58 = 0.345 moles

c) 680 g of NH_3 — 680 / 17 = 40.0 moles

d) 100 g of O_2 — 100 / 32 = 3.13 moles

e) 1 kg of Al_2O_3 — 1000 / 102 = 9.80 moles

f) 20 mg of Au — $0.02 / 197 = 1.02 \times 10^{-4}$ moles

Moles Exercise 2

a) 4 moles of N_2 — 4 x 28 = 112 g

b) 0.1 moles of HNO_3 — 0.1 x 63 = 6.3 g

c) 0.02 moles of K_2O — 0.02 x 94 = 1.88 g

d) 2.5 moles of PH_3 — 2.5 x 34 = 85 g

e) 0.40 moles of C_2H_5OH — 0.4 x 46 = 18.4 g

f) 10 moles of $Ca(OH)_2$ — 10 x 74 = 740 g

Reacting Masses

1) 540 g
2) 4.00 g
3) 13.8 g
4) 113 g
5) 8163 g
6) 3.56 g
7) 525 g
8) 38.0 g
9) 106 g
10) x = 10, M_r = 322

Percentage Yield

1) a) 68g
   b) 29.4%

2) a) 70 g
   b) 29.4%

3) a) 30.3 g
   b) 82.5%

4) a) 684 g
   b) 87.7%

5) a) 2526 g
   b) 77.2%

Reactions of Acids

metal + acid ⟶ salt + hydrogen

metal oxide + acid ⟶ salt + water

metal hydroxide + acid ⟶ salt + water

metal carbonate + acid ⟶ salt + water + carbon dioxide

1) zinc + sulfuric acid → **zinc sulfate + hydrogen**
2) nitric acid + calcium carbonate → **calcium nitrate + water + carbon dioxide**
3) potassium hydroxide + sulfuric acid → **potassium sulfate + water**
4) nitric acid + calcium oxide → **calcium nitrate + water .**
5) nitric acid + ammonia → **ammonium nitrate**
6) **calcium + nitric acid** → calcium nitrate + hydrogen
7) **lead oxide (or lead hydroxide) + sulfuric** acid → lead sulfate + water
8) **zinc carbonate + sulfuric acid** → zinc sulfate + water + carbon dioxide
9) **ammonia + phosphoric acid** → ammonium phosphate
10) calcium carbonate + **hydrochloric acid** → calcium chloride + **water + carbon dioxide**
11) tin oxide + **hydrochloric acid** → tin chloride + **water**
12) calcium hydroxide + **nitric acid** → **water** + calcium nitrate
13) citric acid + potassium hydroxide → **potassium citrate + water**
14) **magnesium** + citric acid → magnesium citrate + hydrogen
15) phosphoric acid + **potassium hydroxide (or potassium oxide)** → potassium phosphate + water